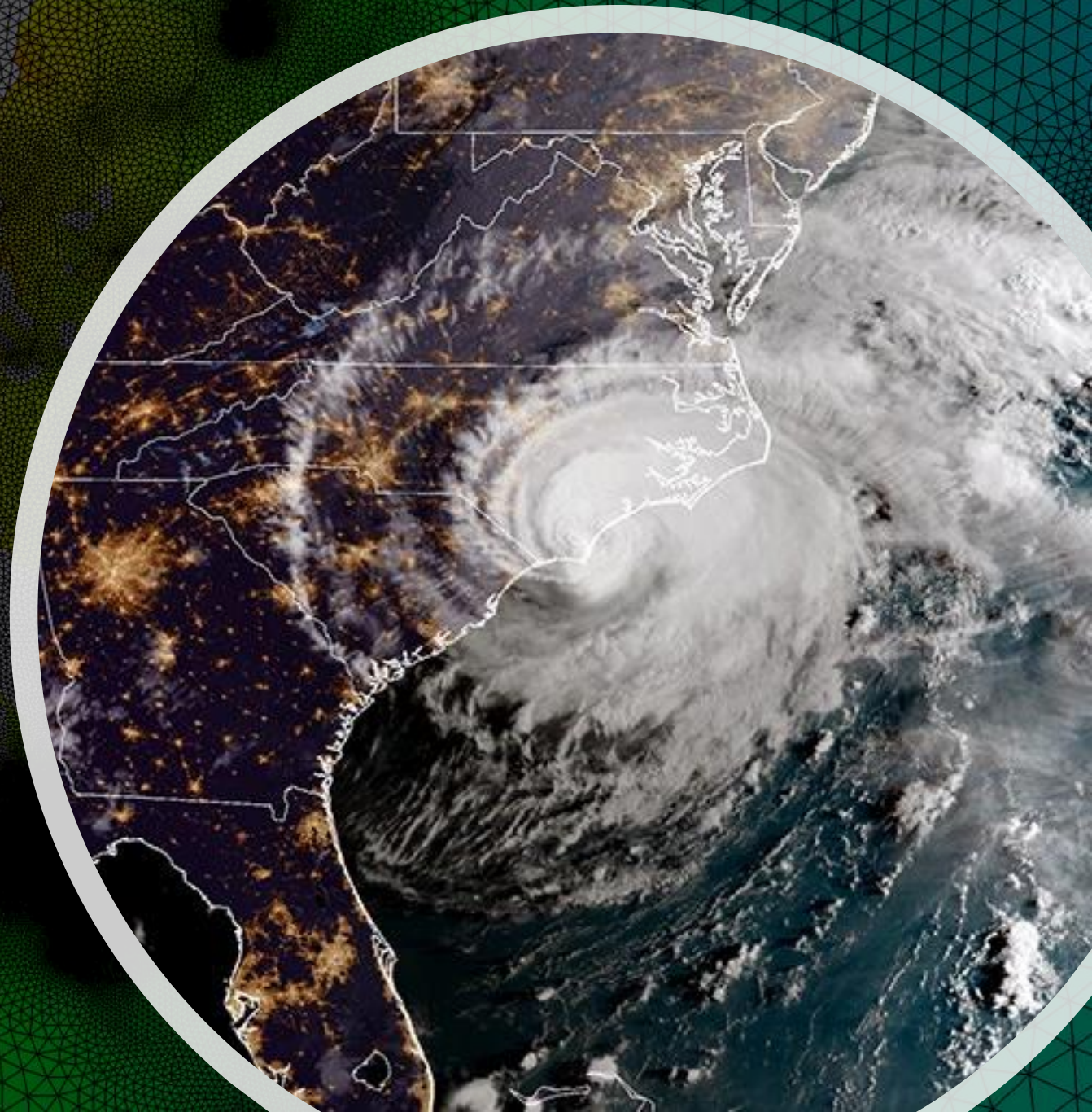
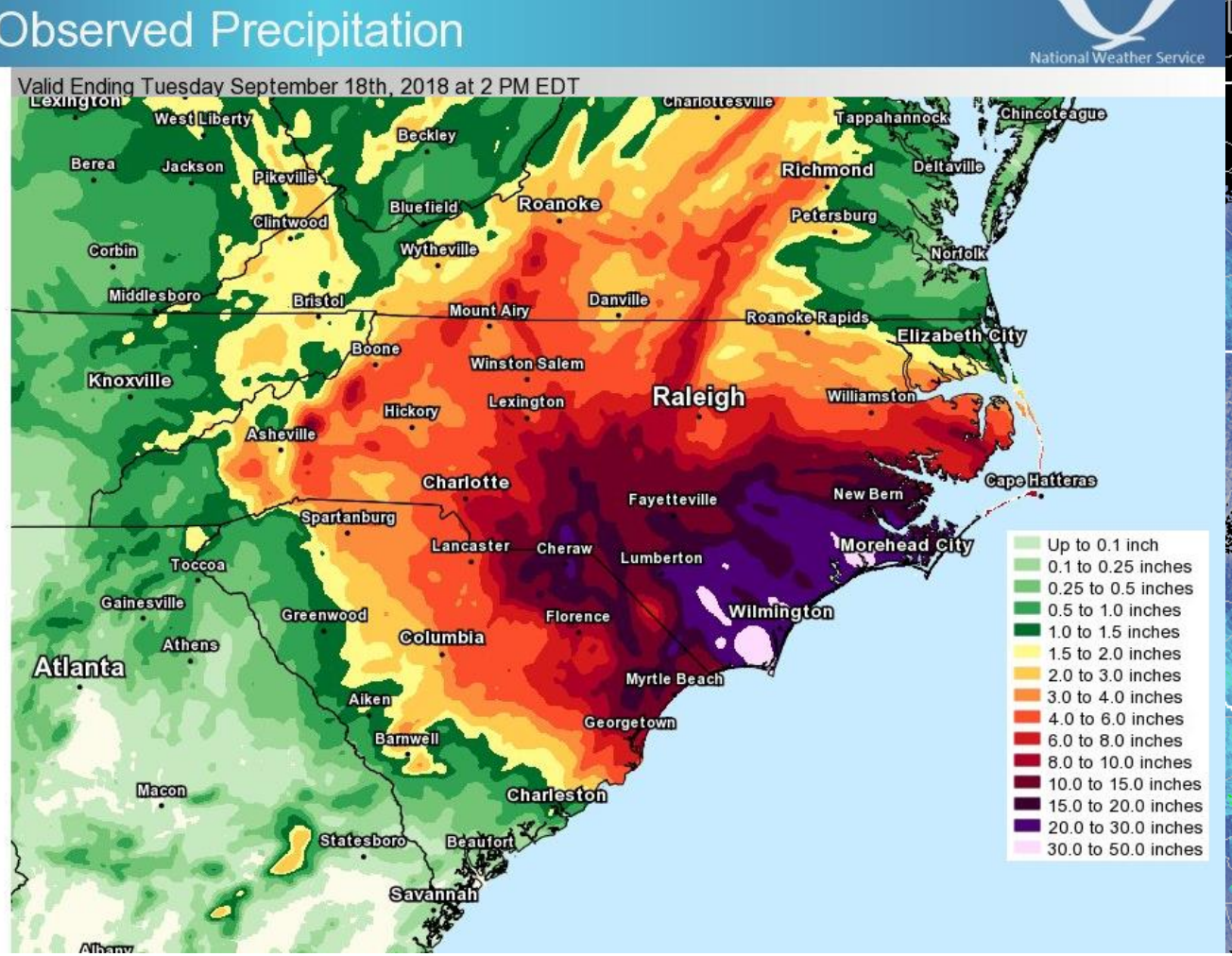
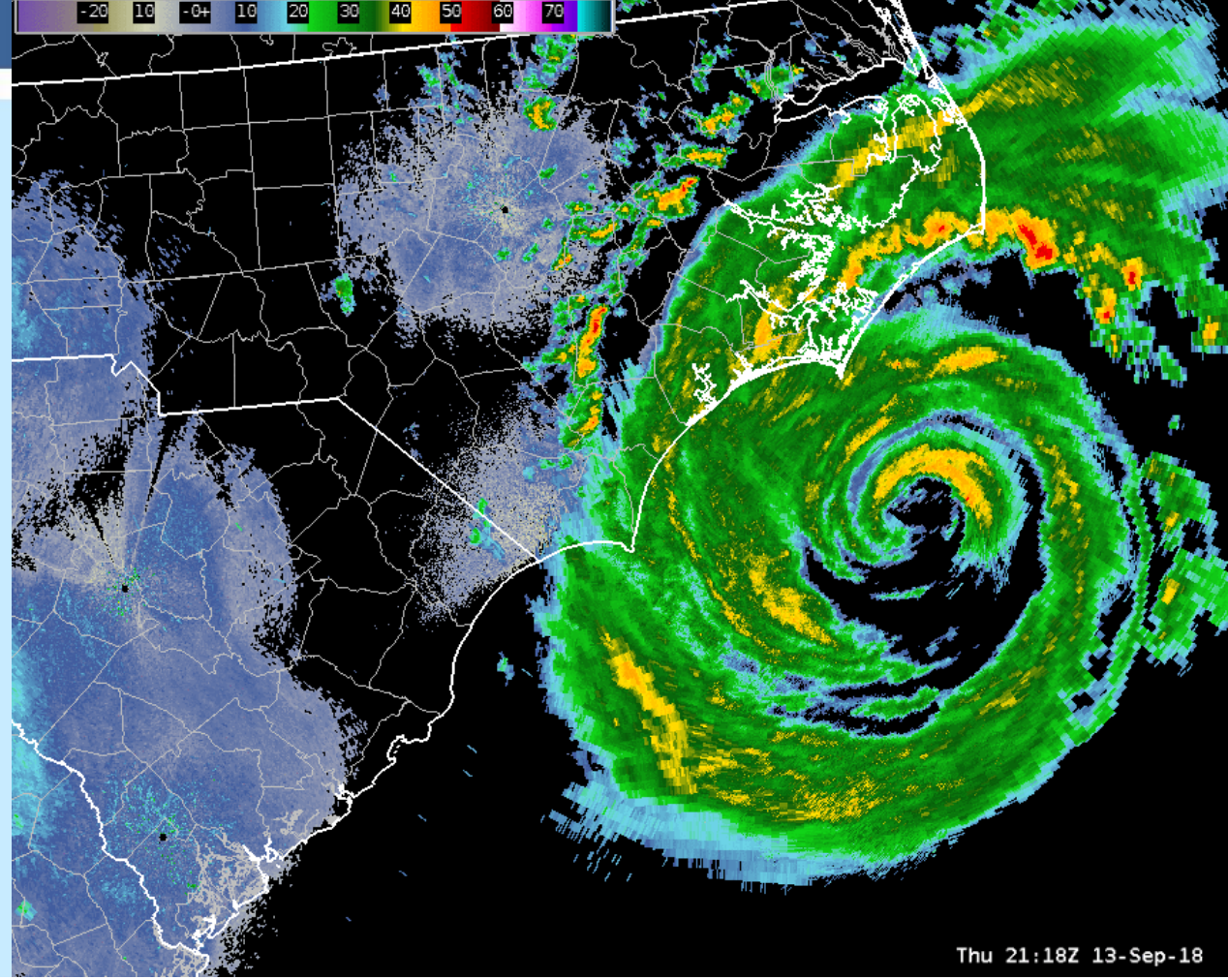
Modeling the Storm Surge and Compound Flooding from Hurricane Florence Using ADCIRC



John Ratcliff
M.S. Student
UNC Institute of Marine Sciences
John.Ratcliff@unc.edu

ADCIRC User's Group Meeting
March 30-31, 2020

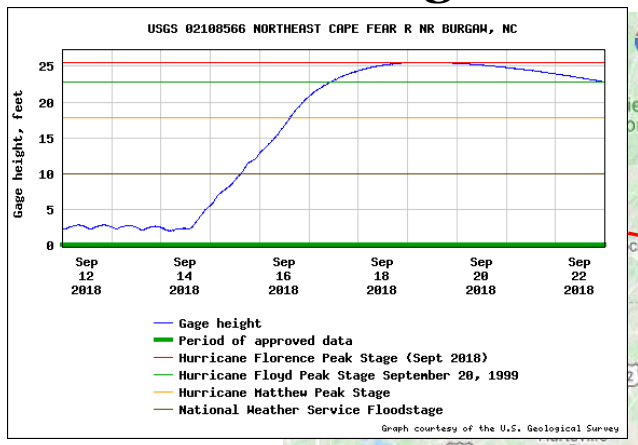




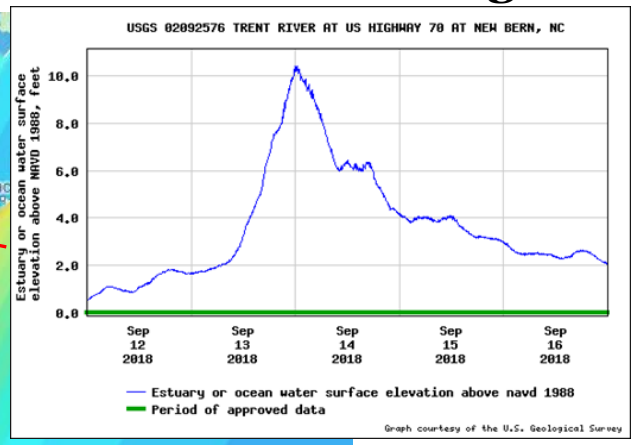
Historic Rainfall with Slow Forward Speed & Extended Duration

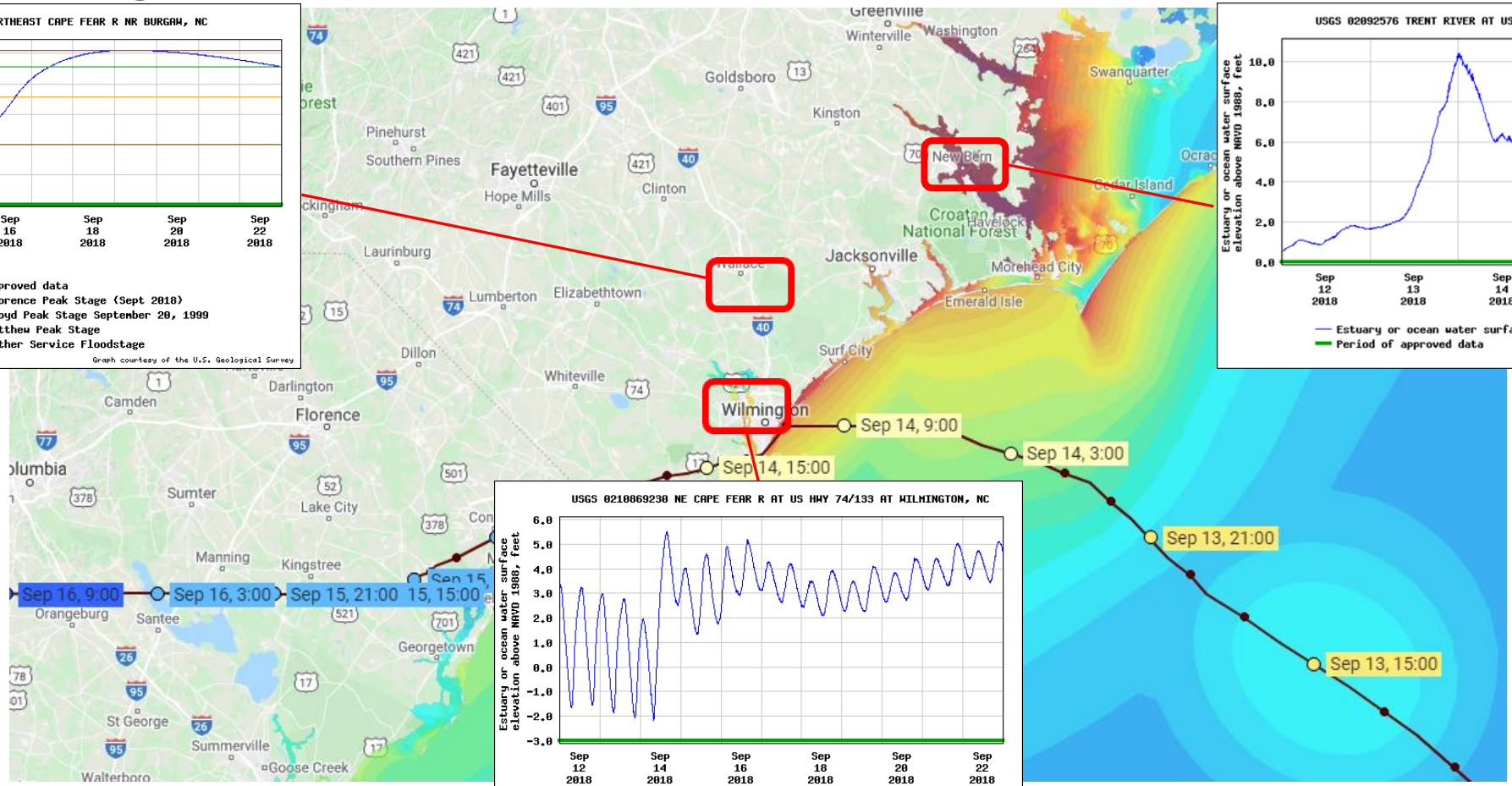
Major Impacts

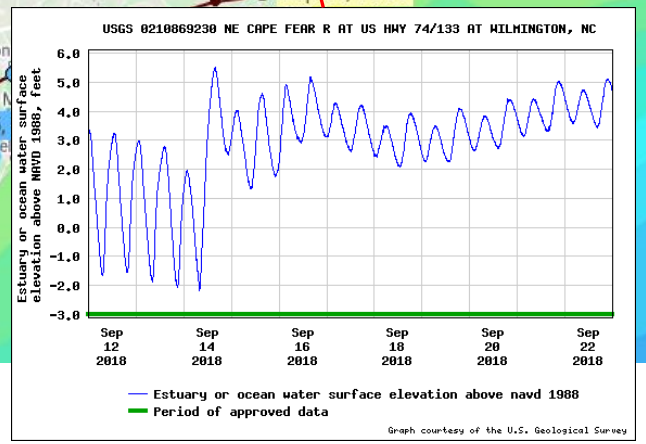
Record Stage



Record Storm Surge



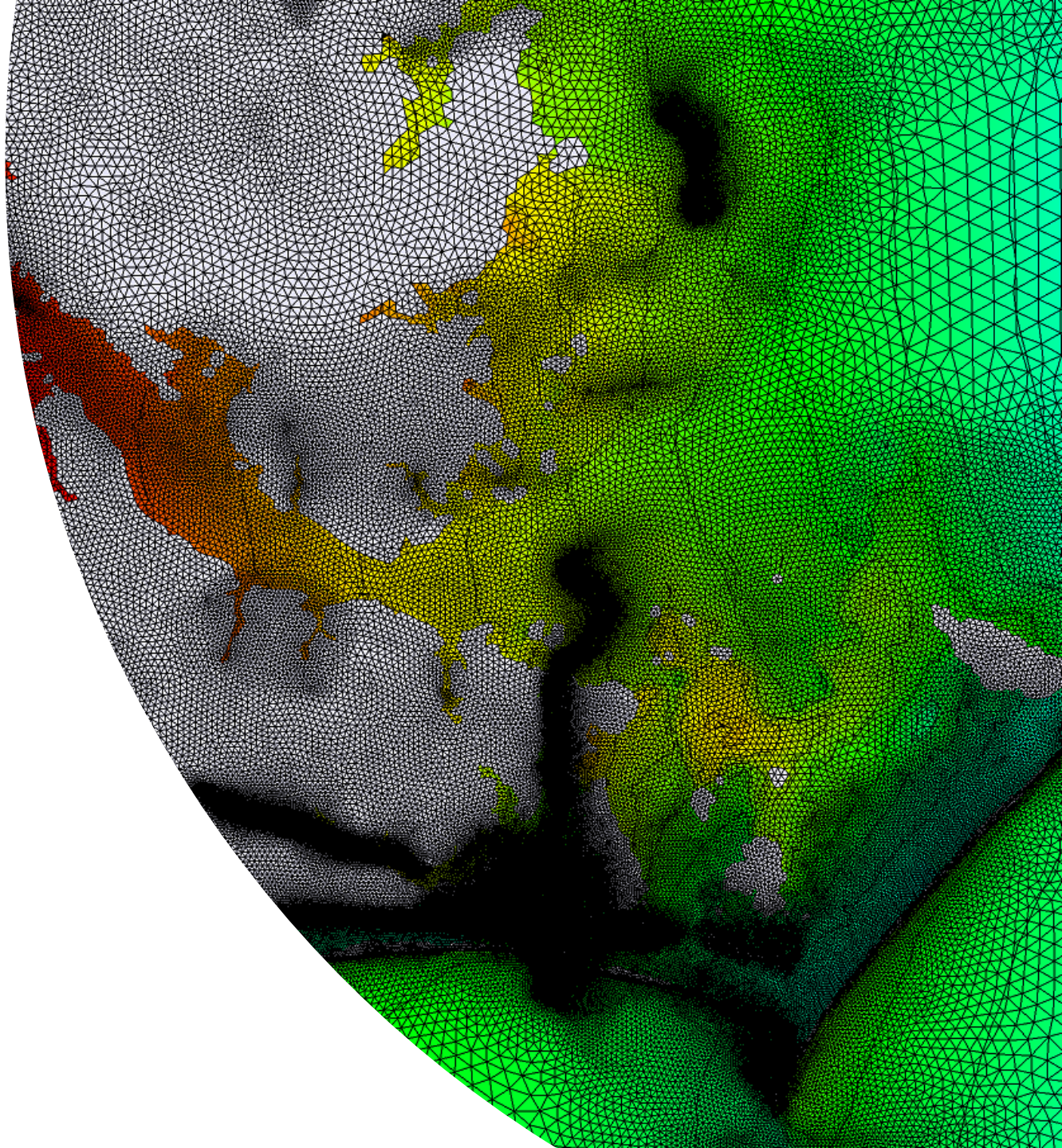




Compound Flooding

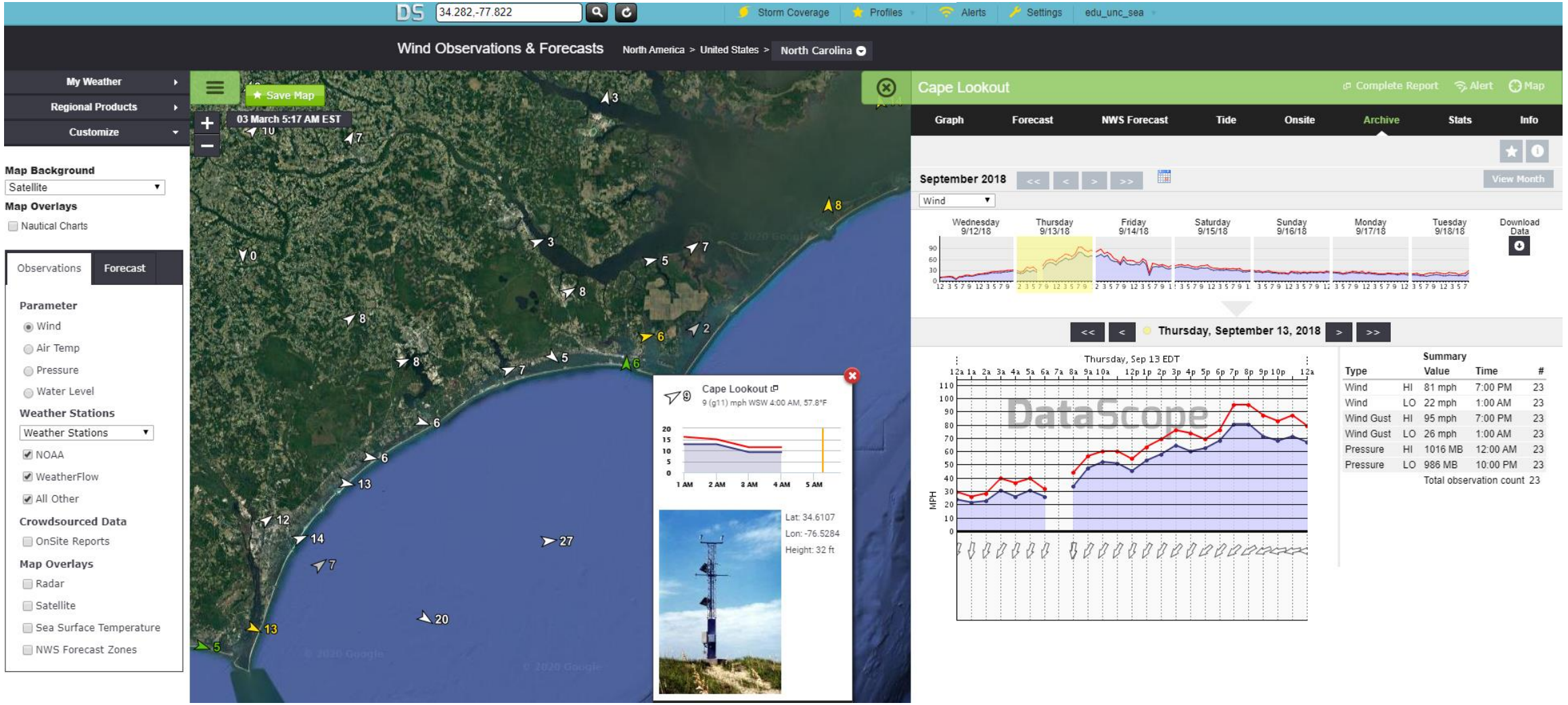
New Opportunities for Study with ADCIRC

- Landfalling East Coast storm with perpendicular approach for ADCIRC skill assessment
- Opportunity to identify/model compound flooding
- Contribute to ‘national’ parameter set for ADCIRC users
- Normalize forecast meteorological product (GAHM) with reanalysis products (OWI)
- Examine datum adjustment (MSL → NAVD88)



Wind Observational Data Acquisition

WeatherFlow



Observational Wind Adjustment to 10 meters

Wind Observation Locations with Height of Station (feet)

Hatteras Landing	35	Roanoke Sound Channel L36	17
Duck Pier	28	Croatan Sound	26
New River	32	Hatteras Airport	32
Mercer Pier	26	REAL Slick	20
Wilmington	32	Cherry Point	
North Myrtle Beach	32	Buxton	34
Beaufort	29	Avon Ocean	39
Durants Neck		Frisco Woods	20
Ocracoke	25	Waves	35
Hofmann State Forest	20	Avon Sound	15
Croatan	20	Frying Pan	
Back Island	20	KHK Resort	53
Sandy Run RAWS	20	Oregon Inlet	34
Lake Mattamuskeet		Oak Island	34
Dare Bomb Range		Fort Macon	34
Cedar Island	20	Davis	
Federal Point	49.5	Sunset Beach Buoy	9
Pamlico Sound	43	Wilmington Buoy	10
Swan Beach		Kill Devil Hills	
New Bern	32	Chadwick Shores	
Sandy Point		N4QLD Hertford	
Pea Ridge		EC Airport	32
Gun Point		Edenton	33
North River	18	Alligator Bridge	38
EW5987 Trent Woods NC US		Manteo	33
TRENT RIVER AT HWY 1 IN TRENTON NC US		Oregon Inlet CG	34
Southern Shores		Cape Lookout	32
Corolla Light		Topsail Beach South	
FW1502 Corolla NC US	20	Creswell	29
		Hatteras High	65
		Sunset	
		Jennettes Pier	60

Wind adjustment to 10 m using 'log law':

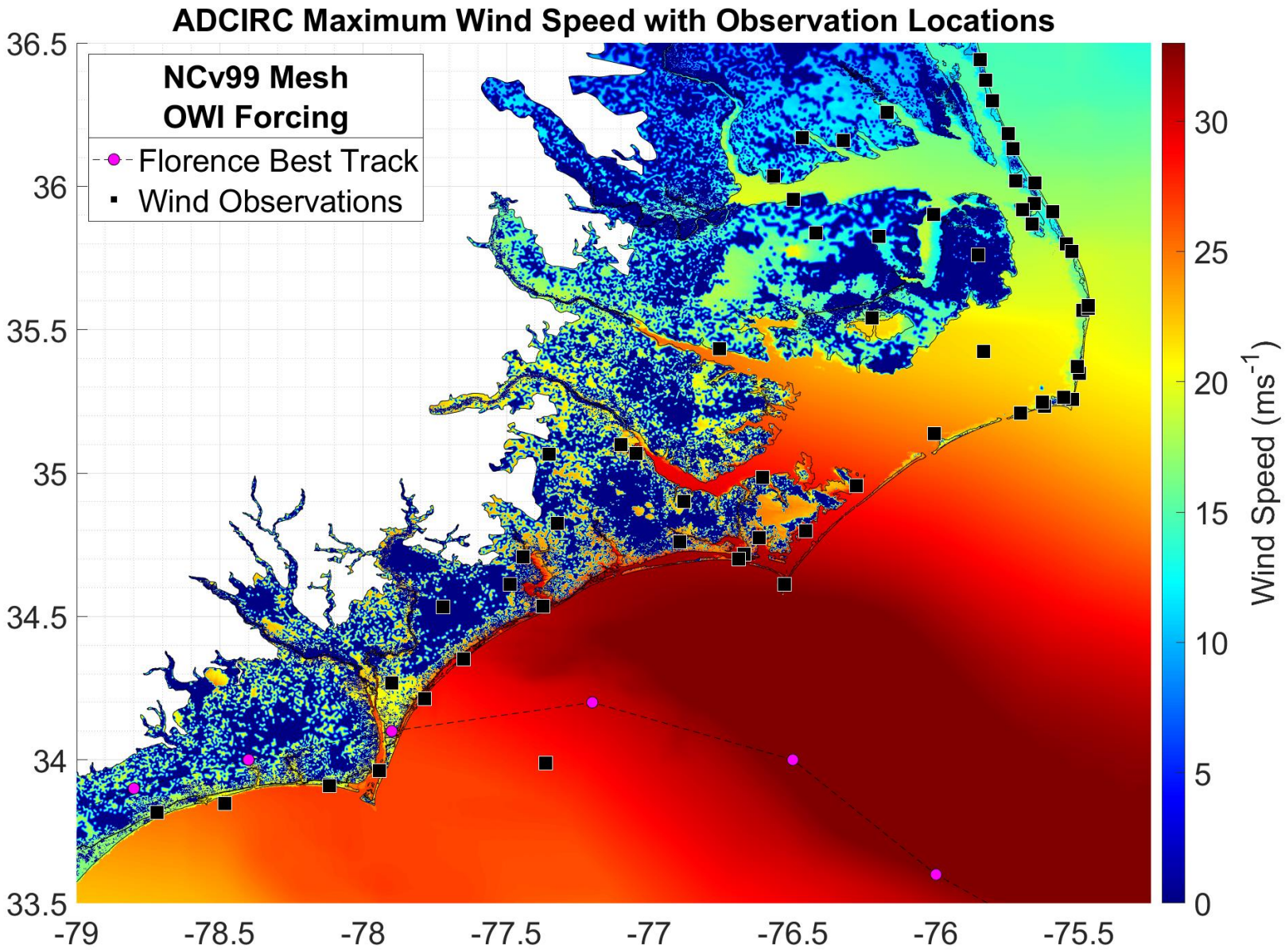
$$U_{10} = U_z \frac{\ln[\frac{10 - Z_D}{Z_0}]}{\ln[\frac{Z - Z_D}{Z_0}]}$$

$U_{10} = 10\ m\ level\ wind\ speed$

$U_z = mean\ surface\ wind\ measurements$

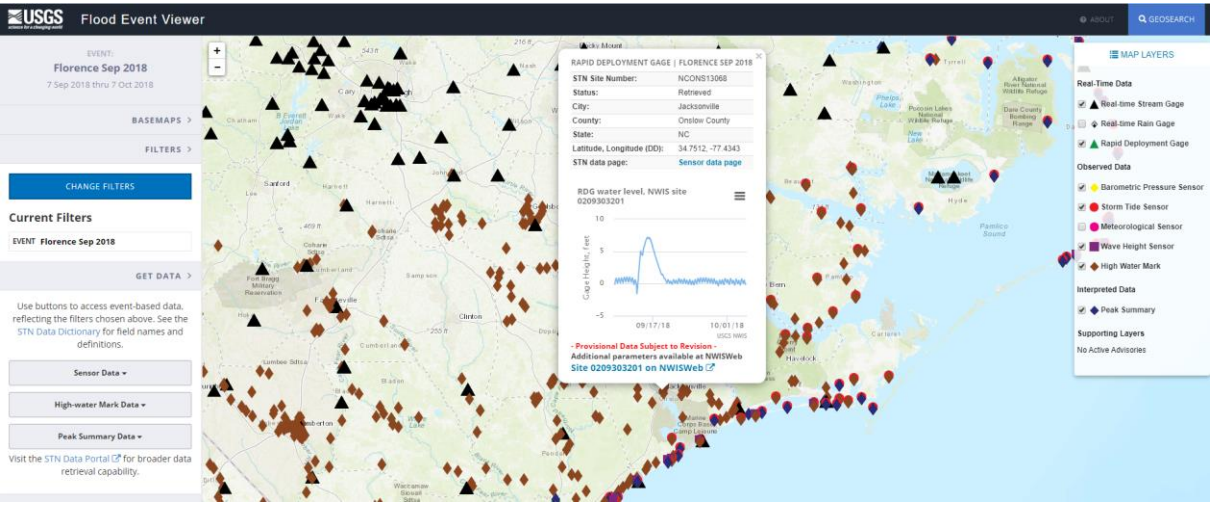
$Z_D = zero - plane\ displacement\ height$

$Z_0 = surface\ roughness\ length$


ADCIRC Maximum Wind Speed with Observation Locations
NCv99 Mesh
OWI Forcing
Florence Best Track
Wind Observations
36.5
36
35.5
35
34.5
34
33.5
-79
-78.5
-78
-77.5
-77
-76.5
-76
-75.5
30
25
20
15
10
5
0
Wind Speed (ms-1)

Water Level Observational Data Acquisition

USGS Flood Event Viewer



NOAA TIDES & CURRENTS

Today's Tides

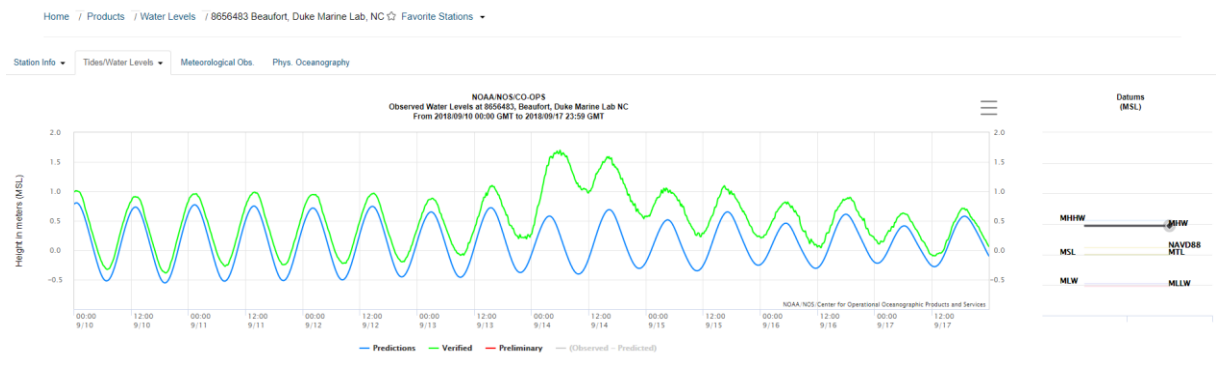
Time	Tide	Height
7:04 PM	Low	0.19 ft
1:28 AM	High	2.85 ft
8:19 AM	**Low**	**0.47 ft**
1:50 PM	High	2.22 ft

Recent Data as of 3/3/2020 5:24 AM Local Time

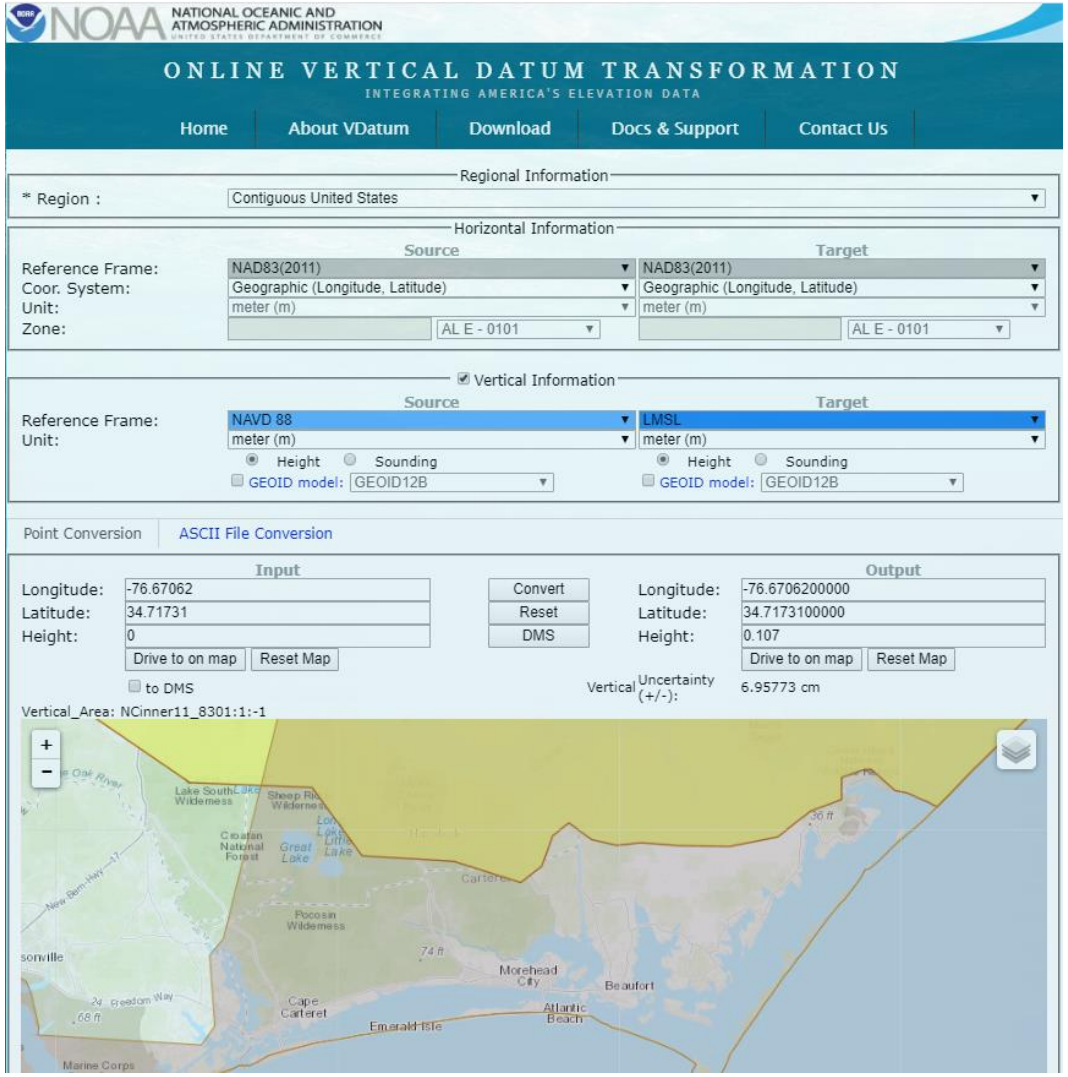
Water Level: 1.39 ft Above MLLW
Next Tide at 8:19 AM: Low 0.47 ft

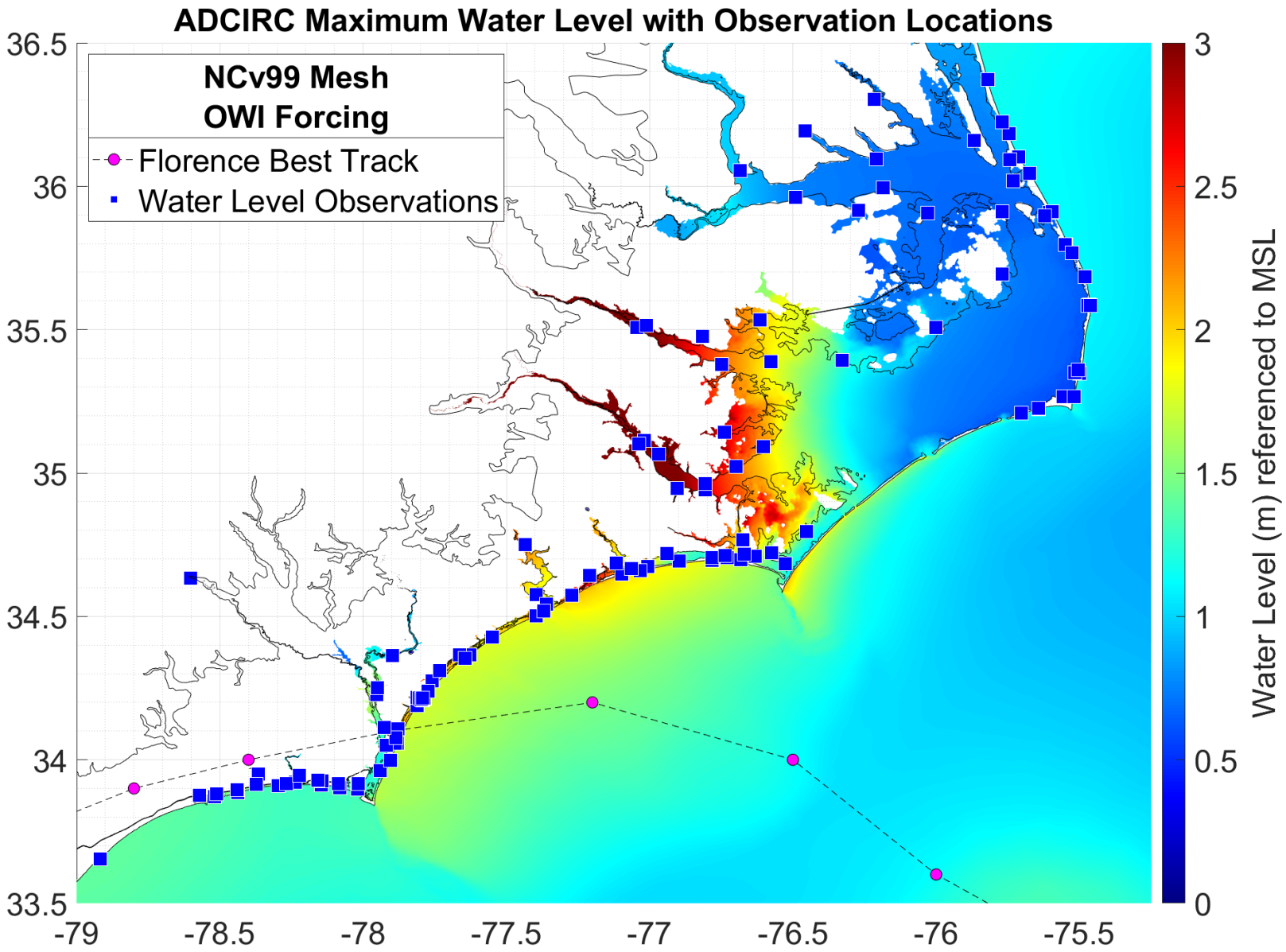
Water Temp: 53.6 ° F
Air Temp: 54.3 ° F
Barometric Pressure: 1013.4 mb
Winds: 3.1 kts from SSW
Gusting to: 3.8 kts from SSW

Plot Data | Standard | Metric | Auto-Refresh:



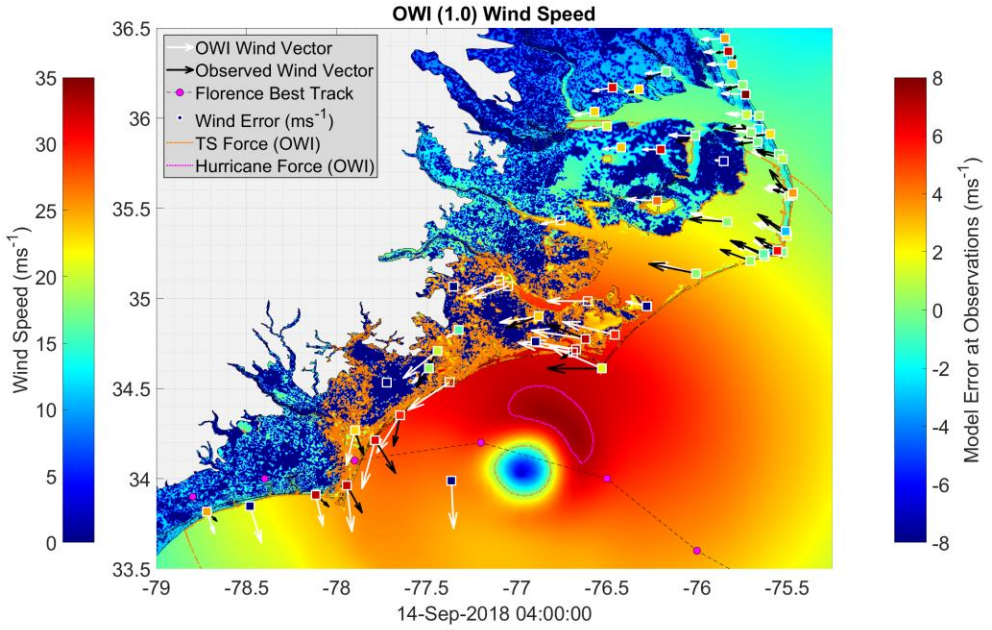
Adjusted Water Level Datums Using NOAA VDatum




ADCIRC Maximum Water Level with Observation Locations
NCv99 Mesh
OWI Forcing
Florence Best Track
Water Level Observations
36.5
36
35.5
35
34.5
34
33.5
-79
-78.5
-78
-77.5
-77
-76.5
-76
-75.5
3
2.5
2
1.5
1
0.5
0
Water Level (m) referenced to MSL

2 Meteorological Forcing Products Used in Study

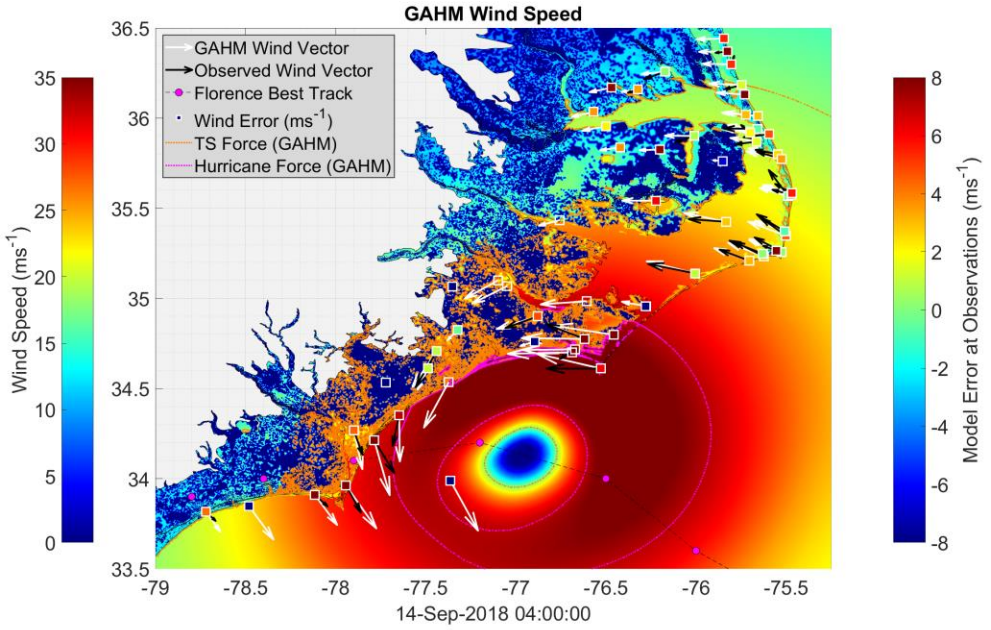
Ocean Weather, Inc. (**OWI**)



Re-analysis Product

Used for hindcast analysis

Generalized Asymmetric Holland Model (**GAHM**), Gao et al. (2017)



Parametric Wind Model that Uses Best Track Data from National Hurricane Center

Used in real-time ADCIRC forecasting

Several Parameter Combinations Compared

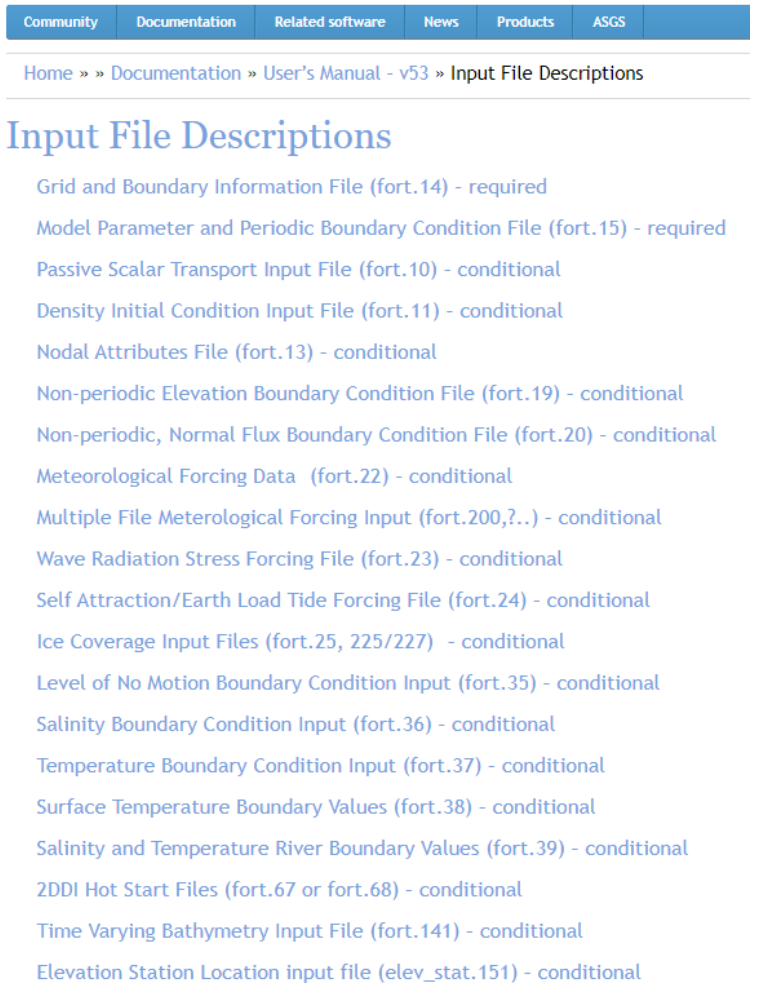
Fort.15 - Model Parameters and Periodic Boundary Conditions

- **FFactor**- Bottom Friction Coefficient
  - Settings used: **0, 0.001, 0.003**
- **WindDragLimit**- Ceiling on Wind Drag Coefficient
  - **0.002, 0.0025, 0.0028**

Fort.22 – Meteorological Forcing Data

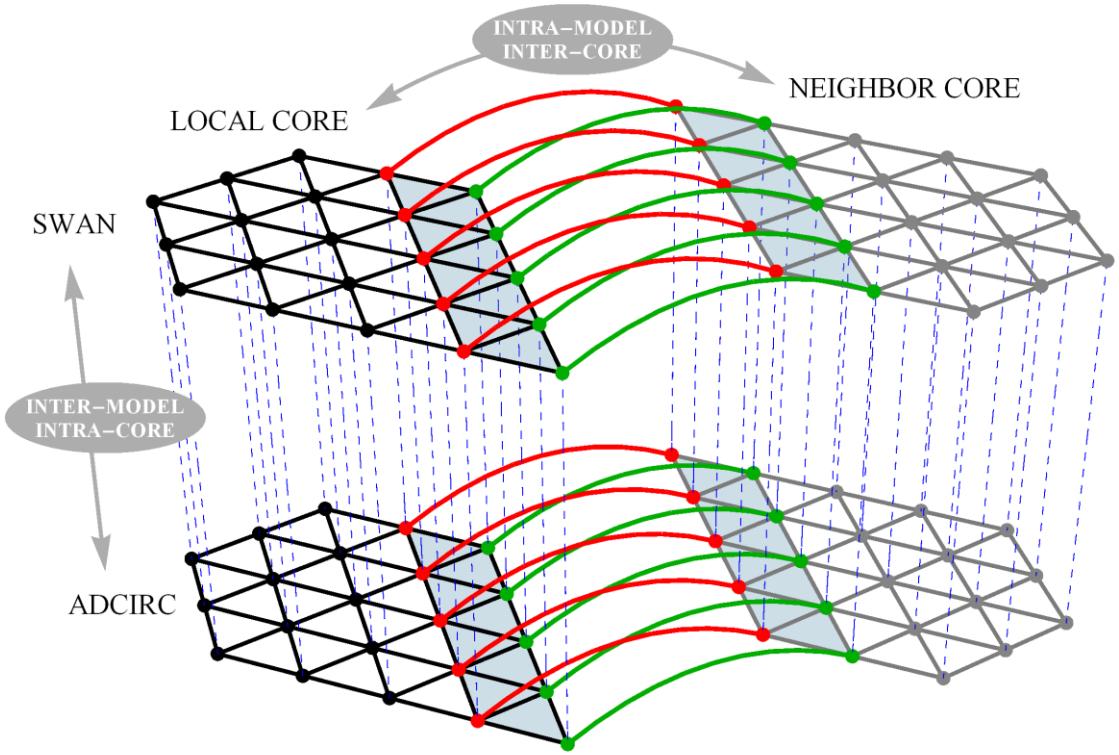
- **DWM (NWM=-312)**- Multiplication Factor for Wind Velocities
  - **1.0, 1.09** (OWI Wind Scaling)

ADCIRC



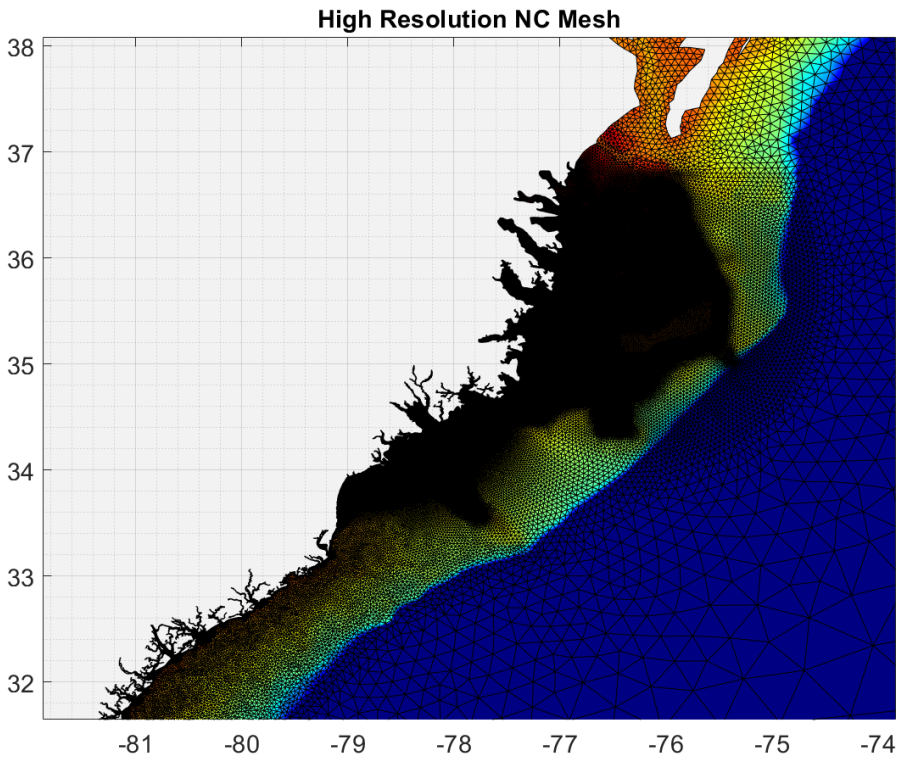
http://adcirc.org/

ADCIRC + SWAN

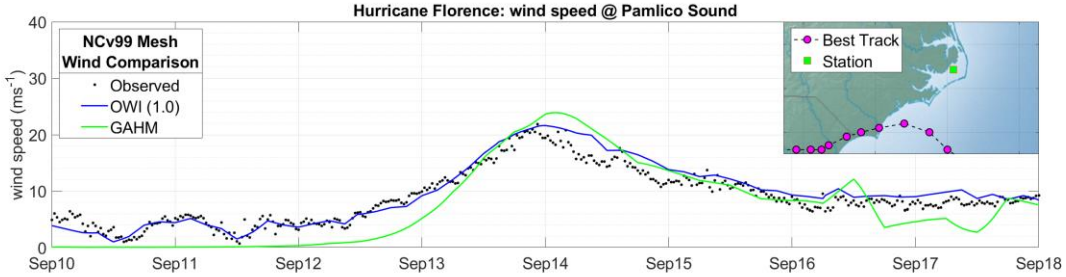


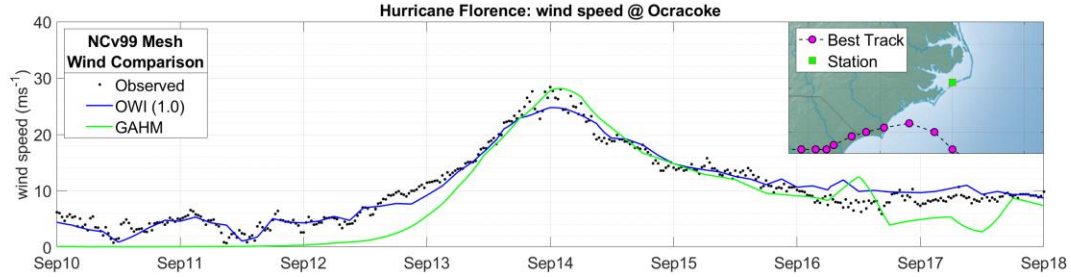
Dietrich et al., 2011

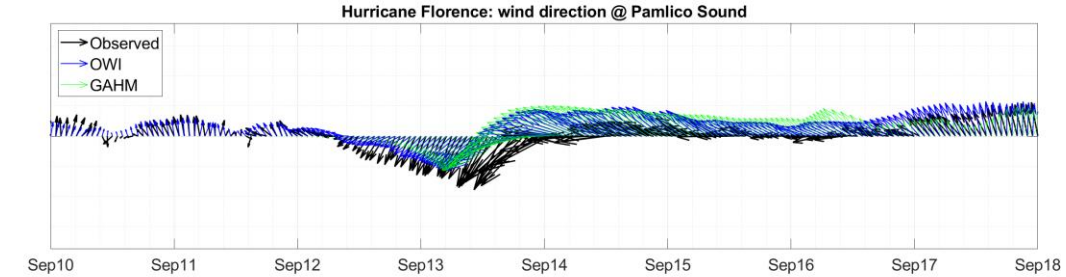
High Res. NC Mesh

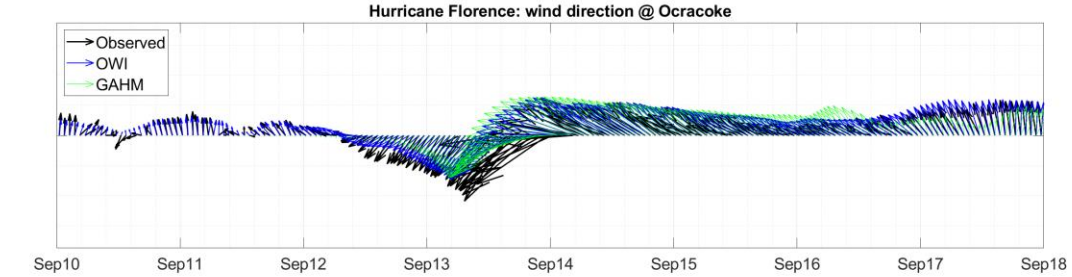


nc_inundation_v9.99a_w_rivers

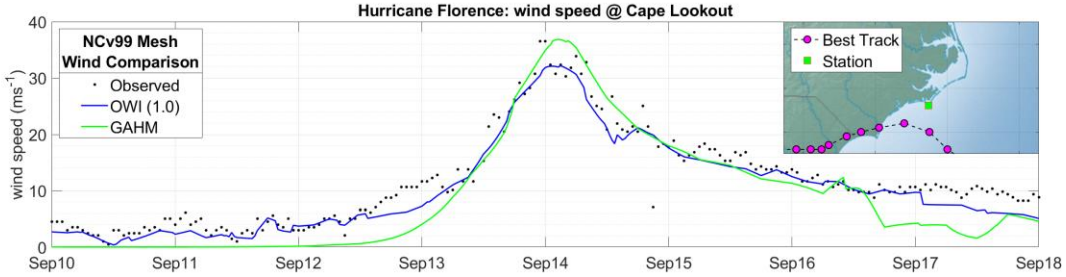


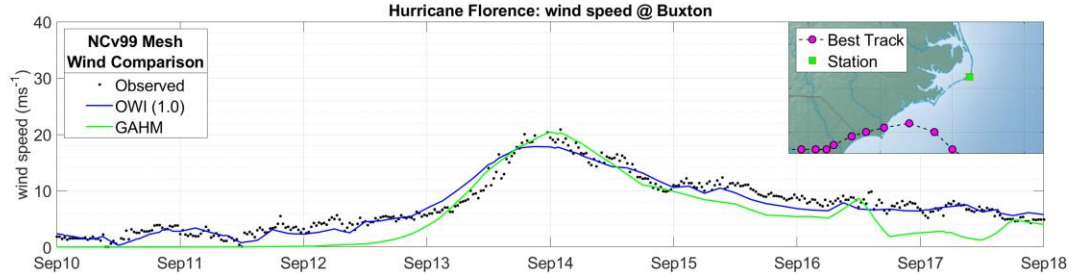


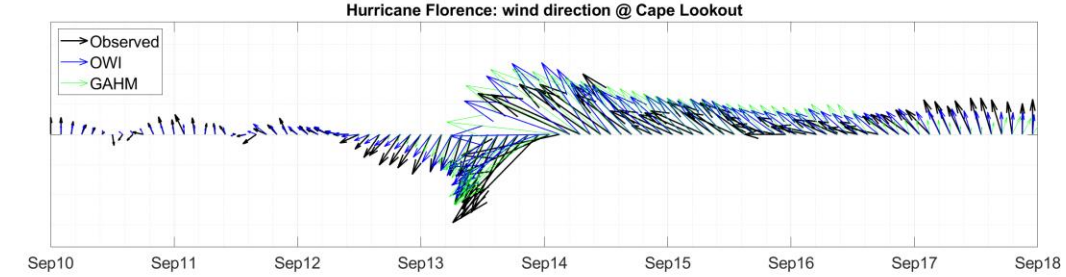


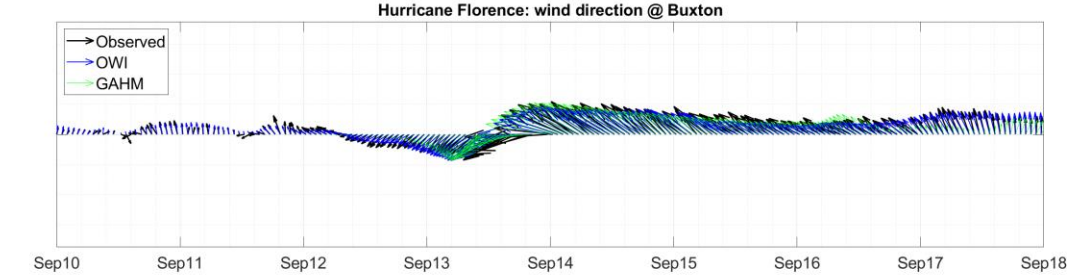


Accurate Winds in Many Locations...

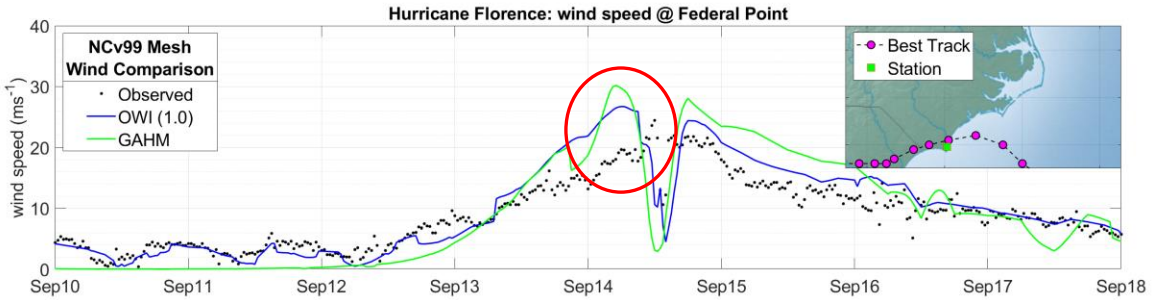


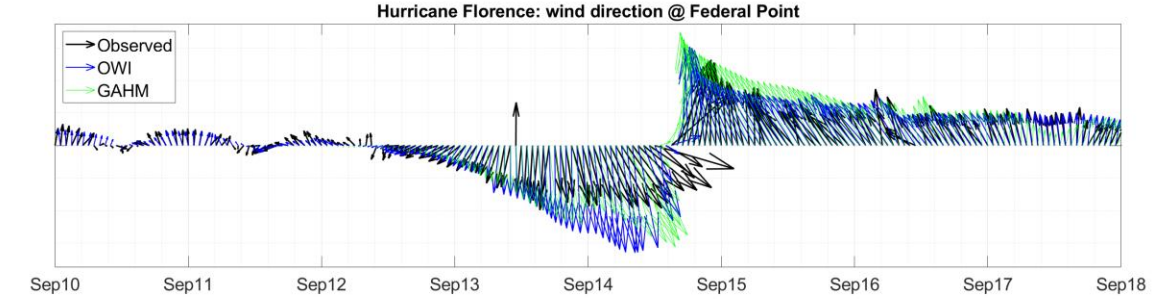


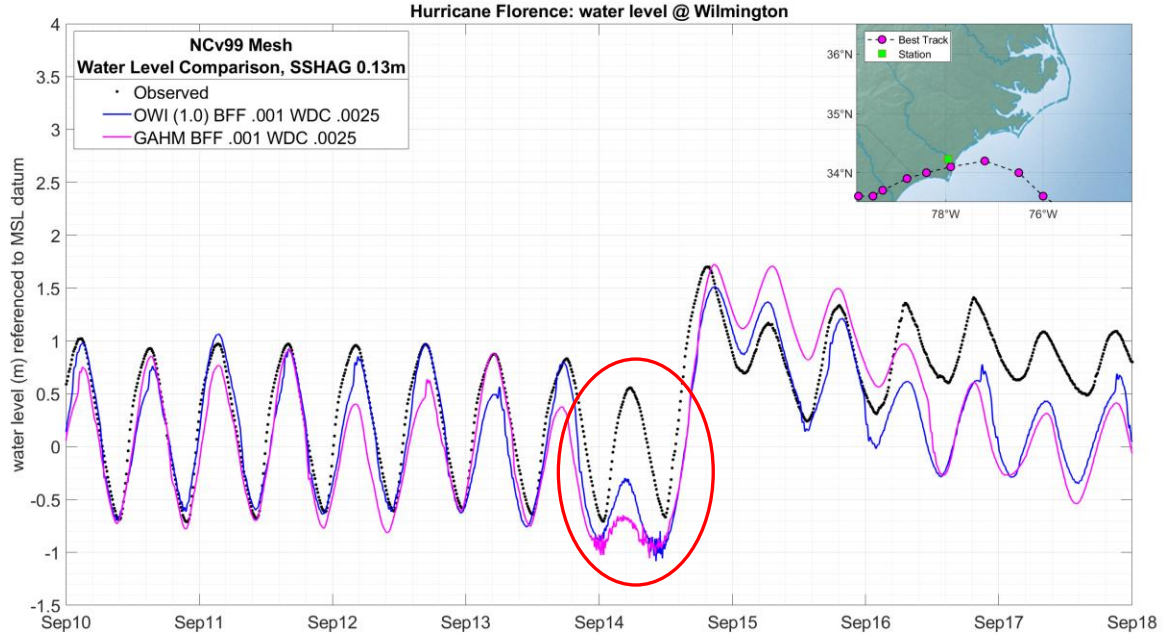




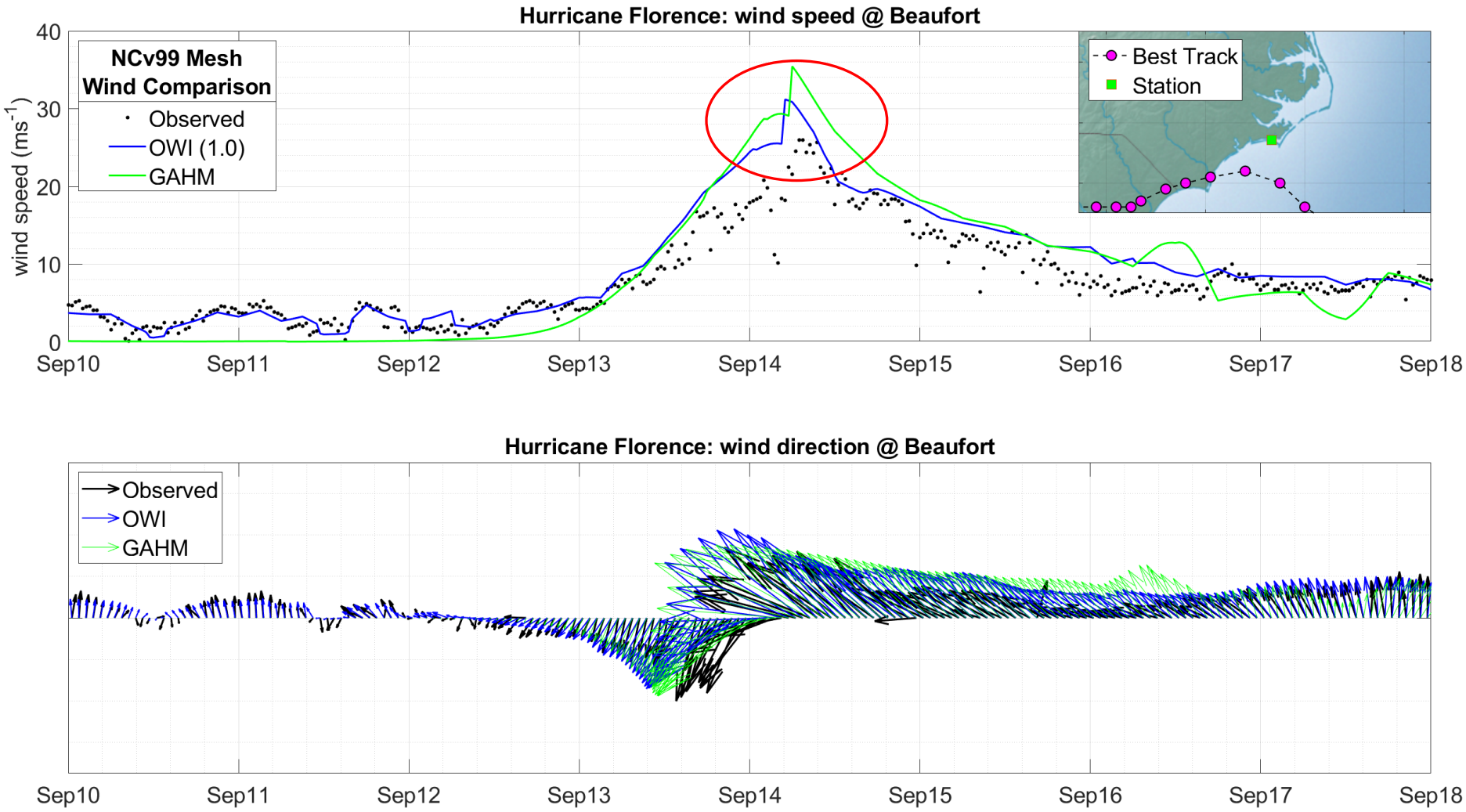
Overpredicted Winds Push Water Out of Cape Fear River



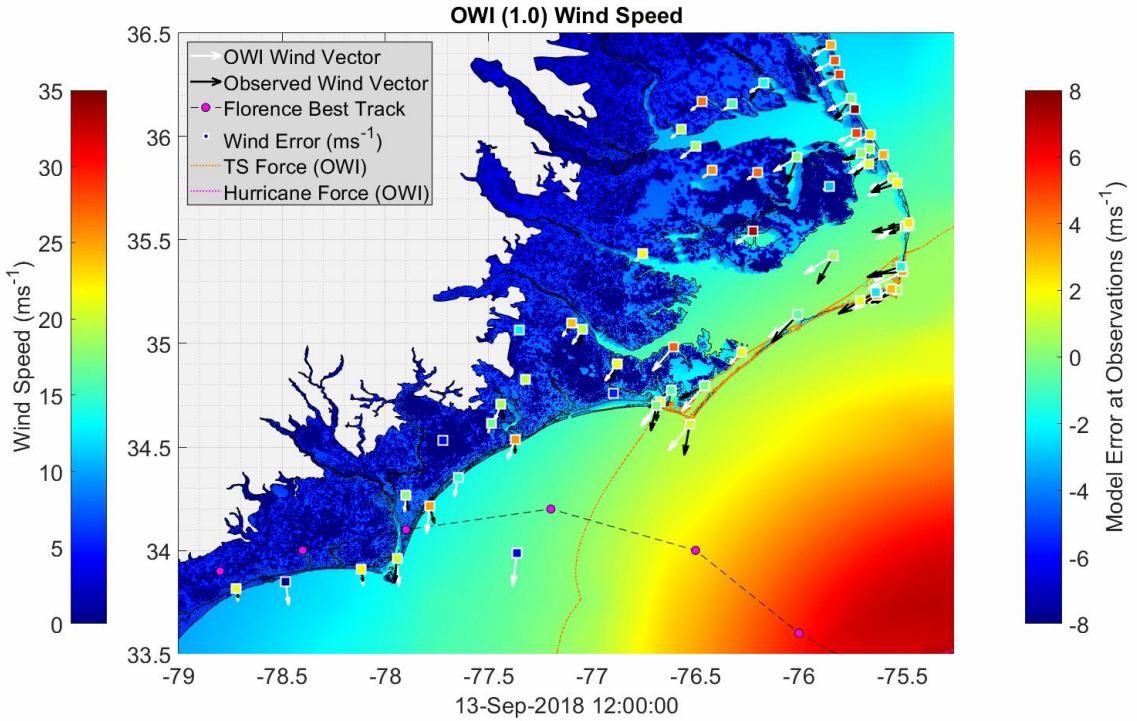




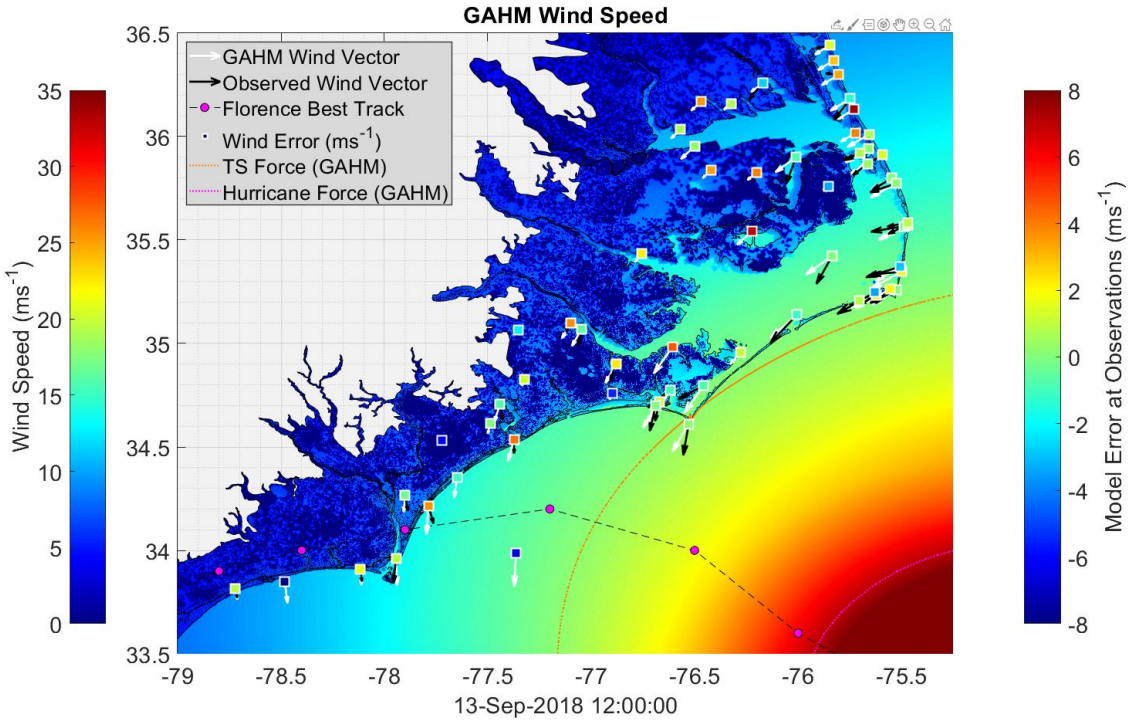
GAHM Winds ~10-20% Stronger than OWI



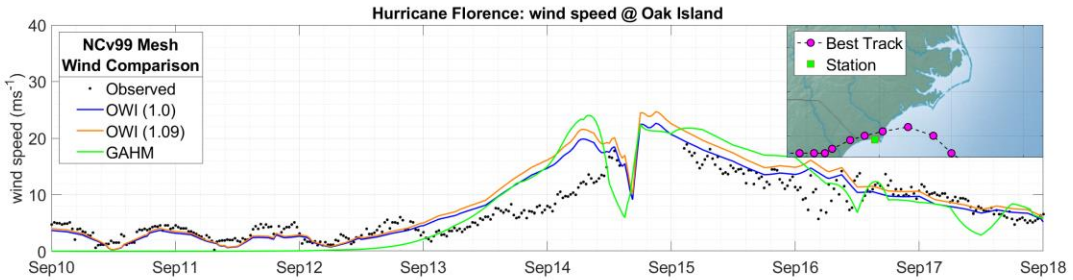
OWI forcing indicates an extended period tropical storm level event

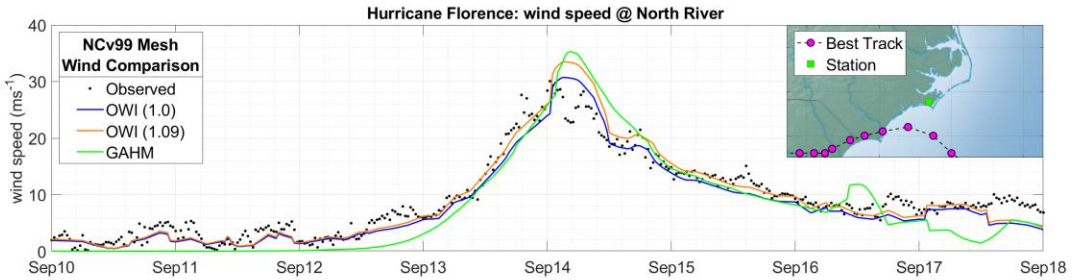


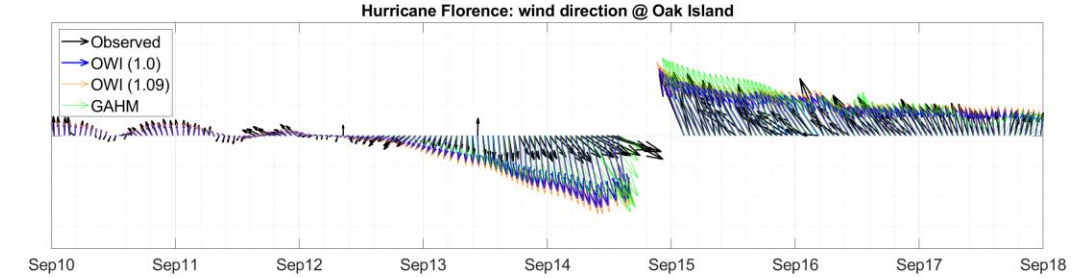
GAHM forcing indicates Cat 1 hurricane winds onshore for an extended period

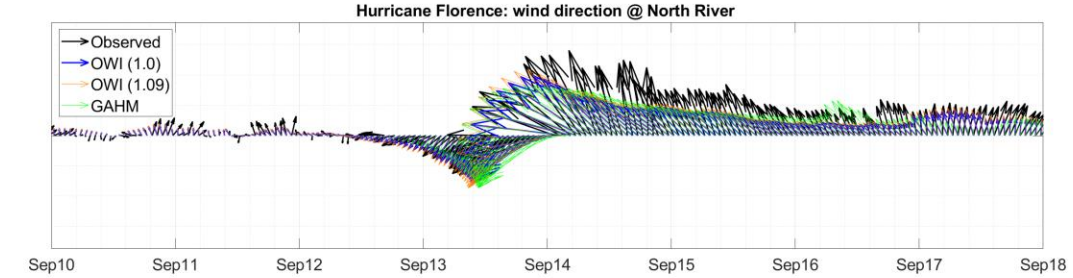


OWI Wind Scaling Unnecessary



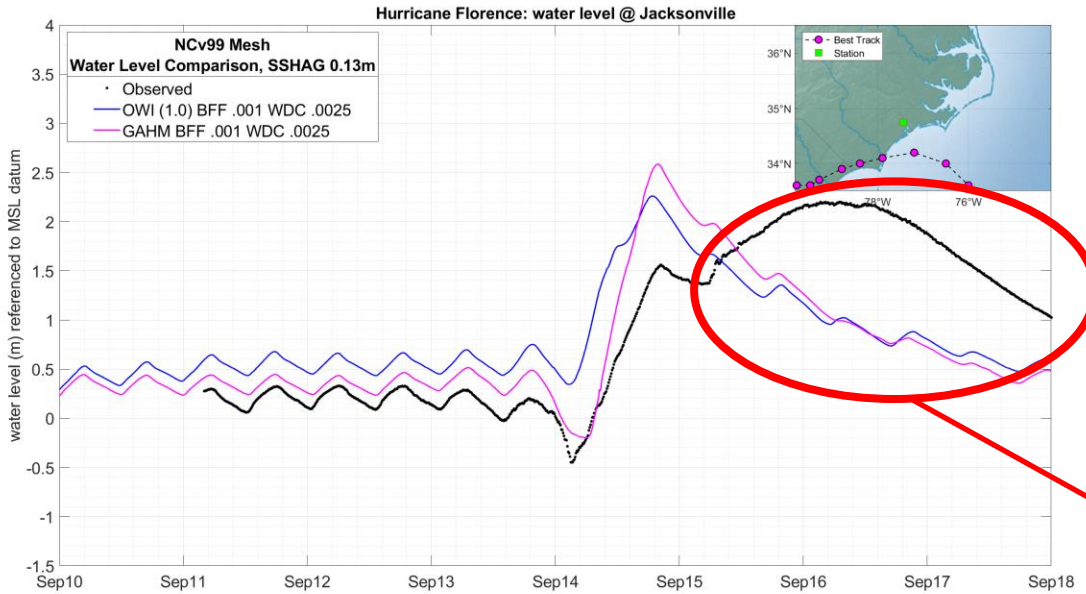


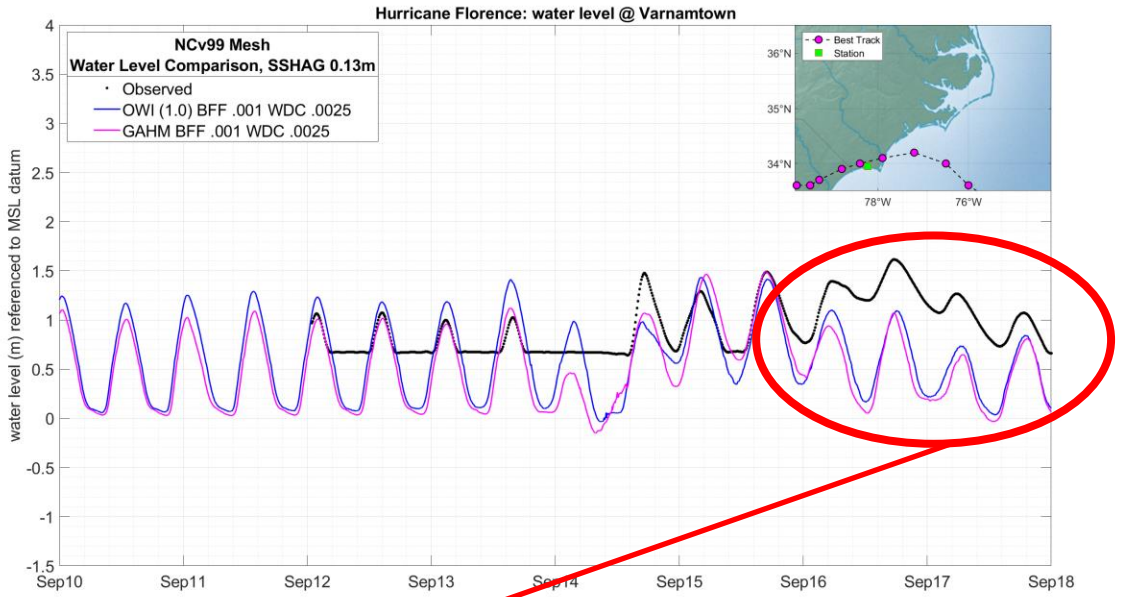




Scale Down GAHM Winds?

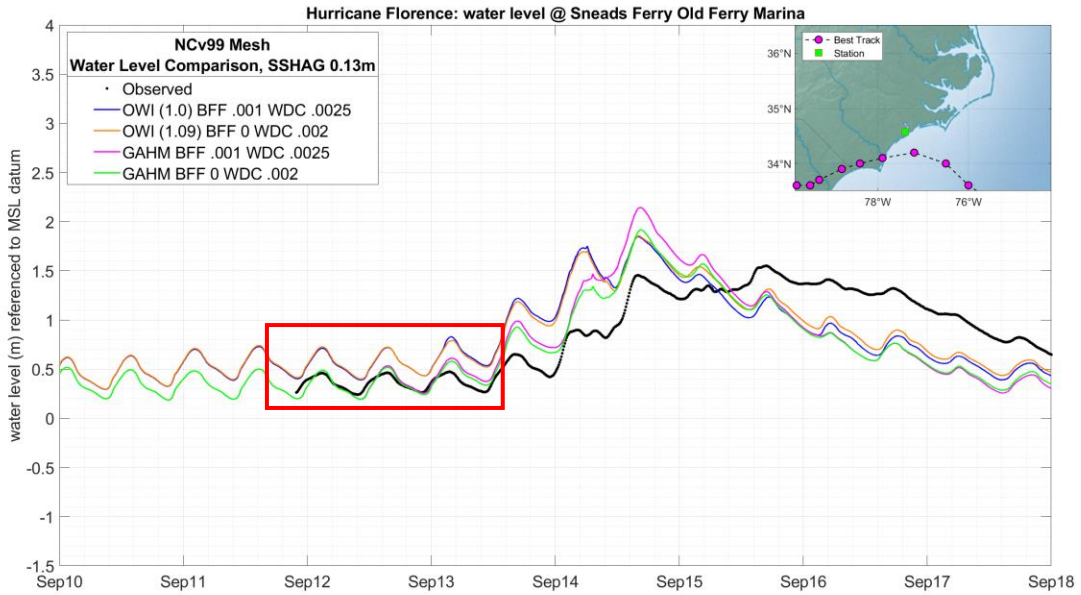
Compound Flooding in Southeastern NC

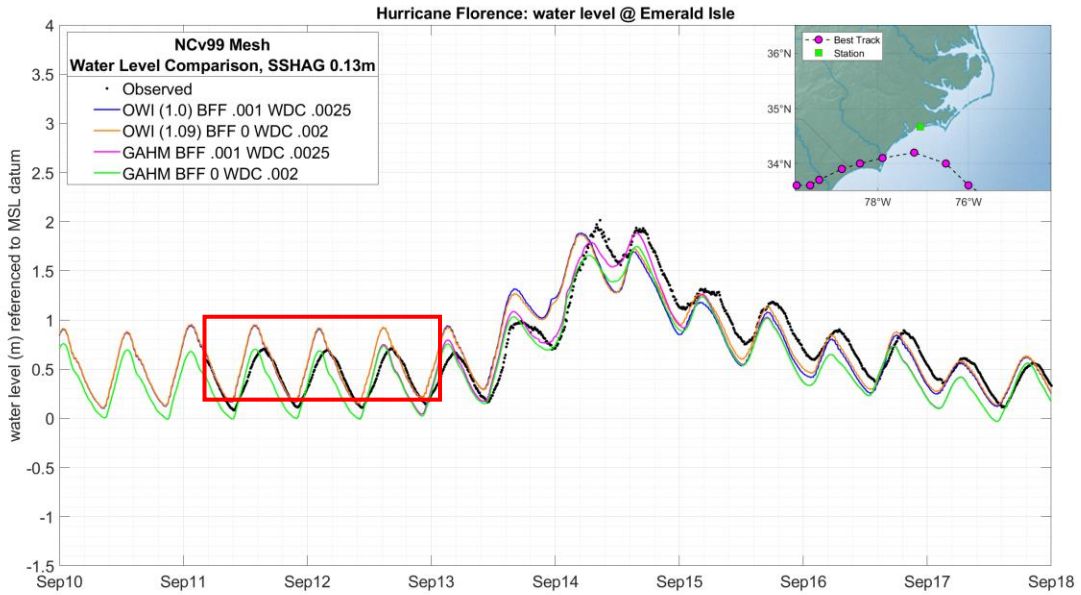




Would like to reproduce these observations with the model

Datum Adjustments?



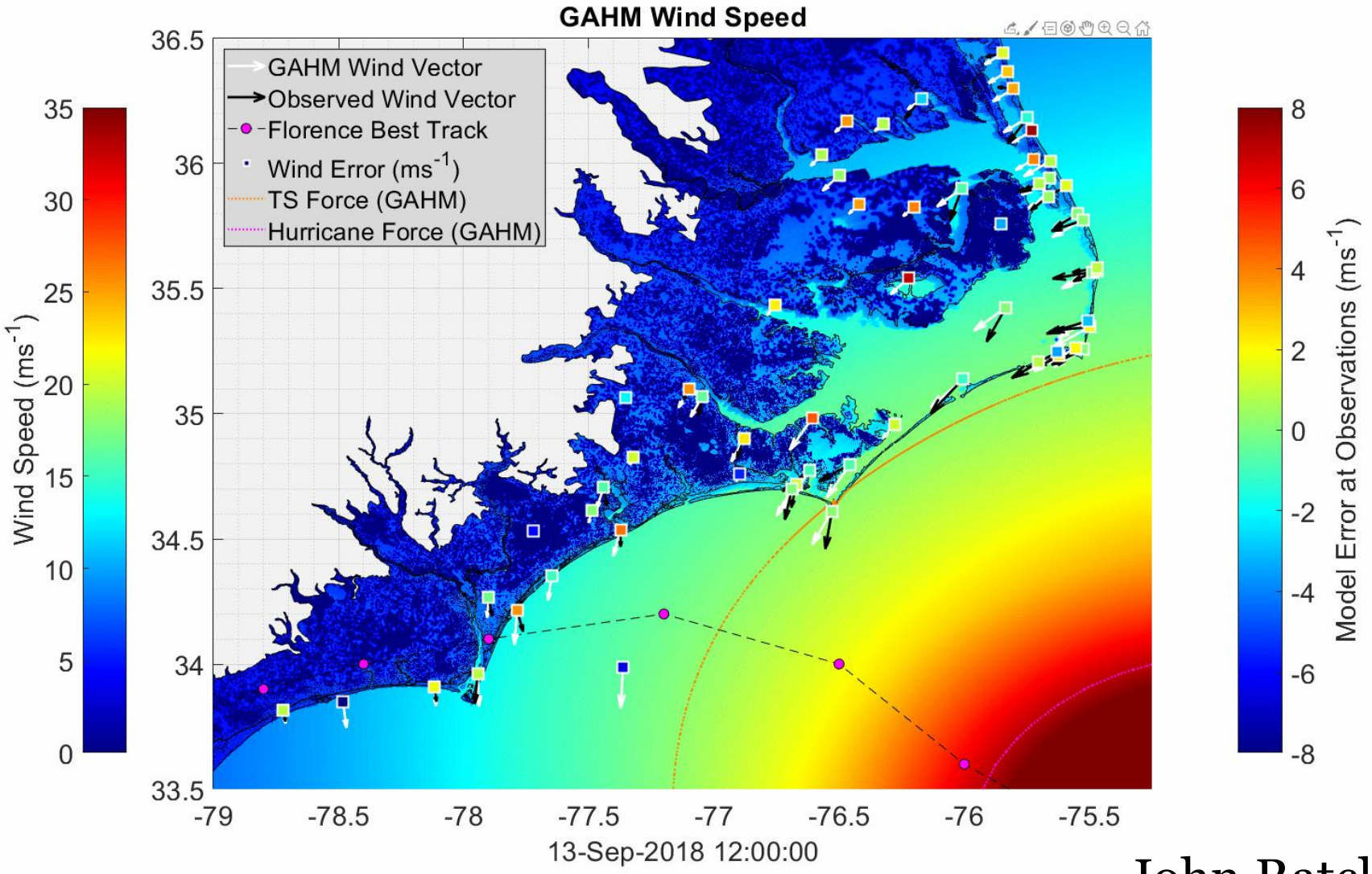


Water level adjustment from MSL to NAVD88:
NOAA NOS tool, **VDatum**
https://vdatum.noaa.gov/vdatumweb/

Upcoming Work

- Add in variable river flow to model compound flooding
- Work on how to best represent model skill statistically
- How to get GAHM (real-time forcing) performing closer to OWI (hindcast forcing)?
- Explore datum conversions in intracoastal/estuarine areas

Thank You, Questions?



John.Ratcliff@unc.edu